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Bhatia et al.

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(54) **CHASSIS MANAGEMENT IMPLEMENTATION BY MANAGEMENT INSTANCE ON BASEBOARD MANAGEMENT CONTROLLER MANAGING MULTIPLE COMPUTER NODES**

(71) Applicant: **American Megatrends, Inc.**, Norcross, GA (US)

(72) Inventors: **Anurag Bhatia**, Lilburn, GA (US); **Winston Thangapandian**, Duluth, GA (US)

(73) Assignee: **AMERICAN MEGATRENDS, INC.**, Norcross, GA (US)

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G06F 11/30	(2006.01)
H04L 12/24	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 41/0213*** (2013.01); ***G06F 11/3003*** (2013.01); ***G06F 13/42*** (2013.01); ***H04L 12/2419*** (2013.01); ***H04L 12/2424*** (2013.01); ***H04L 12/2459*** (2013.01); ***H04L 41/20*** (2013.01)

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CPC . H04L 41/0213; H04L 41/20; H04L 12/2419; H04L 12/2424; H04L 12/2459; G06F 11/3006; G06F 11/3055

See application file for complete search history.

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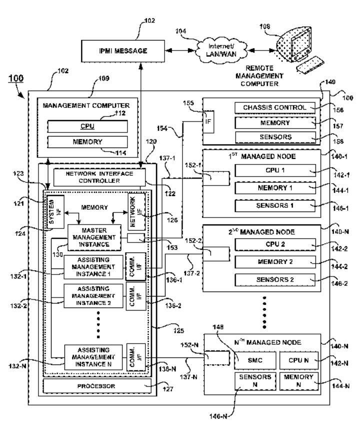
Primary Examiner — Ryan Stiglic

(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Tim Tingkang Xia, Esq.

(57) **ABSTRACT**

Certain aspects of the present disclosure are directed to a baseboard management controller (BMC). The BMC includes a processor and a memory having firmware. The firmware includes a master management instance and a plurality of assisting management instances. When the firmware is executed at the processor, the master management instance is configured to manage a chassis of a computer system, and each of the assisting management instances is configured to manage at least one health or performance related aspect a respective different computer node of a plurality of computer nodes of the computer system.

20 Claims, 6 Drawing Sheets



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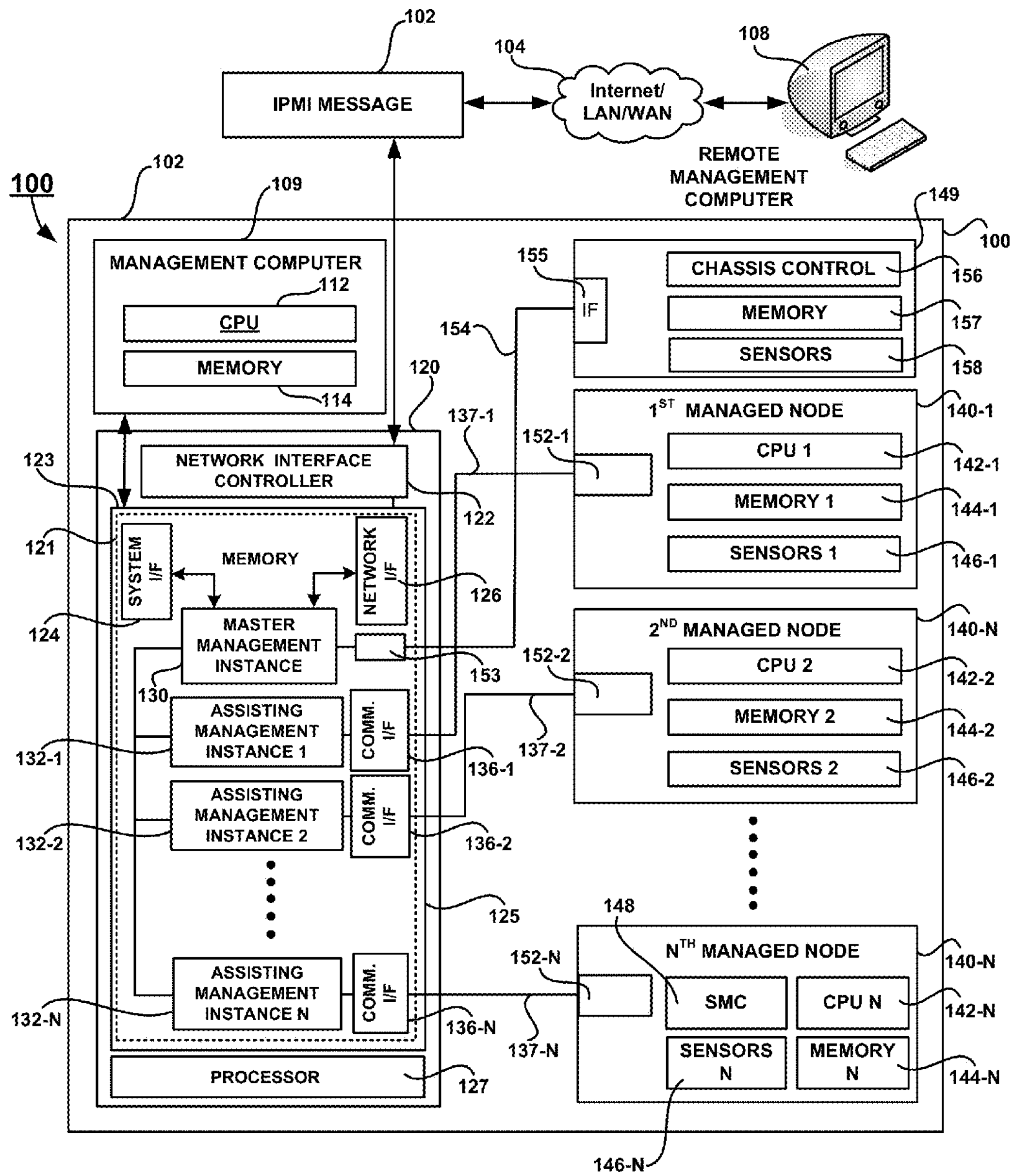
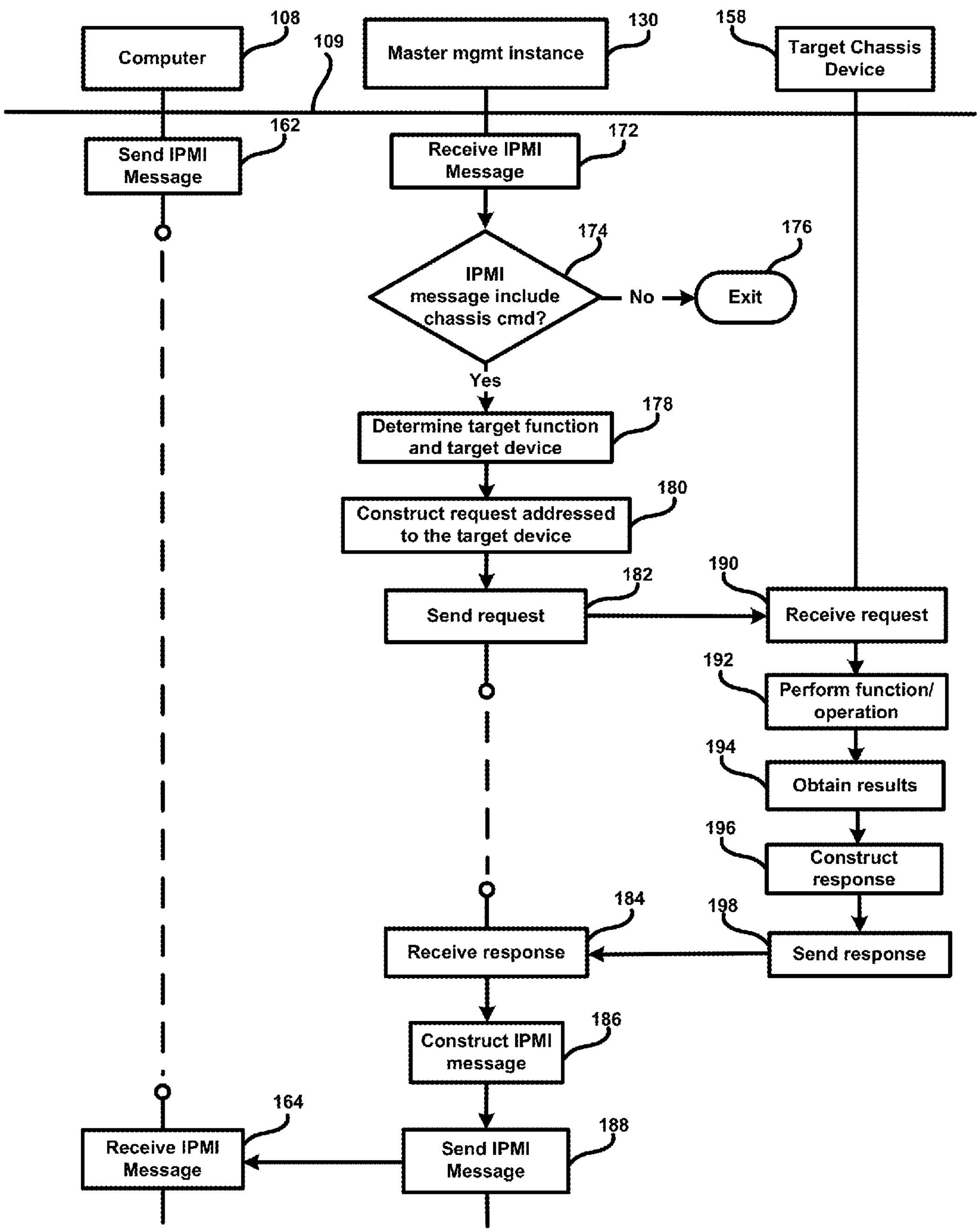

102
IPMI MESSAGE
104
Internet/ LAN/WAN
108
REMOTE MANAGEMENT COMPUTER
100
102
109
MANAGEMENT COMPUTER
112
CPU
MEMORY
114
120
NETWORK INTERFACE CONTROLLER
122
123
121
SYSTEM I/F
MEMORY
NETWORK I/F
126
124
MASTER MANAGEMENT INSTANCE
153
130
ASSISTING MANAGEMENT INSTANCE 1
COMM. I/F
132-1
136-1
ASSISTING MANAGEMENT INSTANCE 2
COMM. I/F
132-2
136-2
125
ASSISTING MANAGEMENT INSTANCE N
COMM. I/F
132-N
136-N
137-N
PROCESSOR
127
149
100
155
IF
CHASSIS CONTROL
156
MEMORY
157
SENSORS
158
154
137-1
152-1
1ST MANAGED NODE
140-1
CPU 1
142-1
MEMORY 1
144-1
SENSORS 1
146-1
2ND MANAGED NODE
140-N
152-2
CPU 2
142-2
MEMORY 2
144-2
137-2
SENSORS 2
146-2
148
152-N
NTH MANAGED NODE
140-N
SMC
CPU N
142-N
SENSORS N
MEMORY N
144-N
146-N

FIG. 1A



Computer
108
109
Master mgmt instance
130
158
Target Chassis Device
Send IPMI Message
162
Receive IPMI Message
172
174
IPMI message include chassis cmd?
No
Exit
176
Yes
Determine target function and target device
178
Construct request addressed to the target device
180
Send request
182
190
Receive request
192
Perform function/ operation
194
Obtain results
196
Construct response
198
Send response
Receive response
184
Construct IPMI message
186
Send IPMI Message
188
Receive IPMI Message
164

FIG. 1B

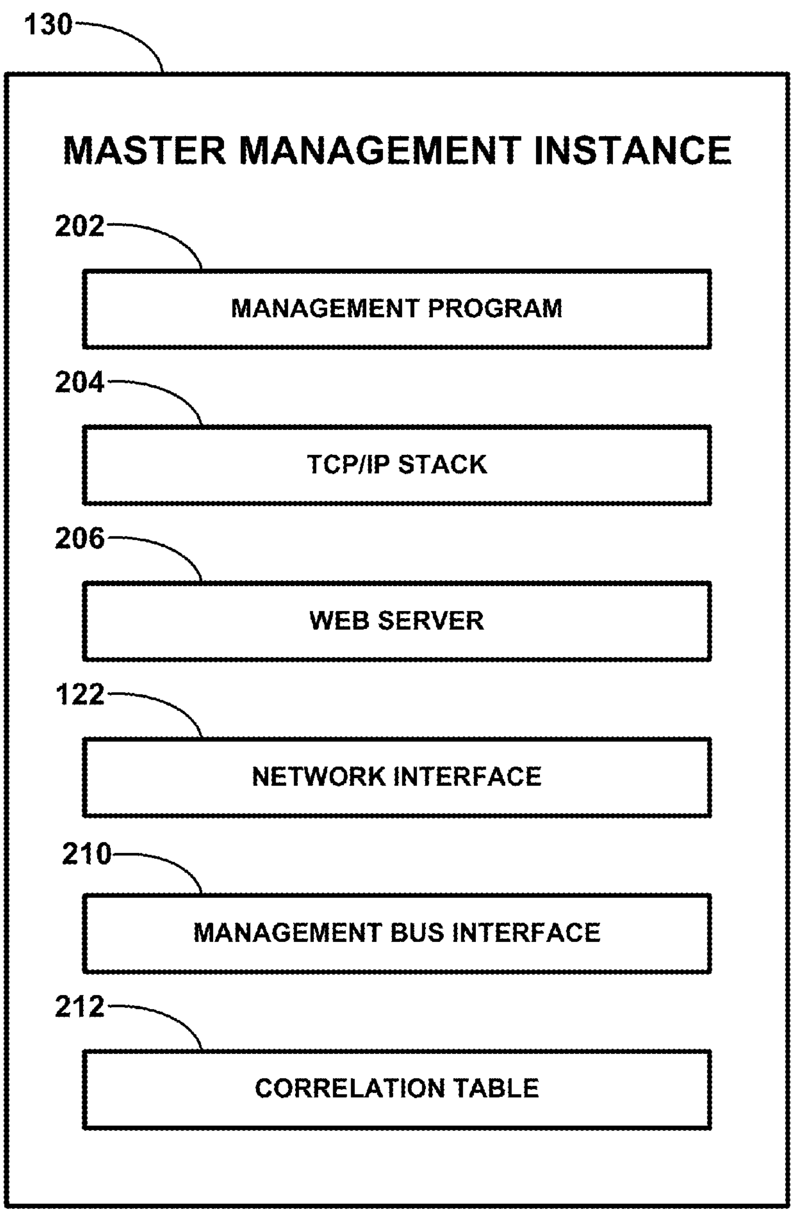

130
MASTER MANAGEMENT INSTANCE
202
MANAGEMENT PROGRAM
204
TCP/IP STACK
206
WEB SERVER
122
NETWORK INTERFACE
210
MANAGEMENT BUS INTERFACE
212
CORRELATION TABLE

FIG. 2

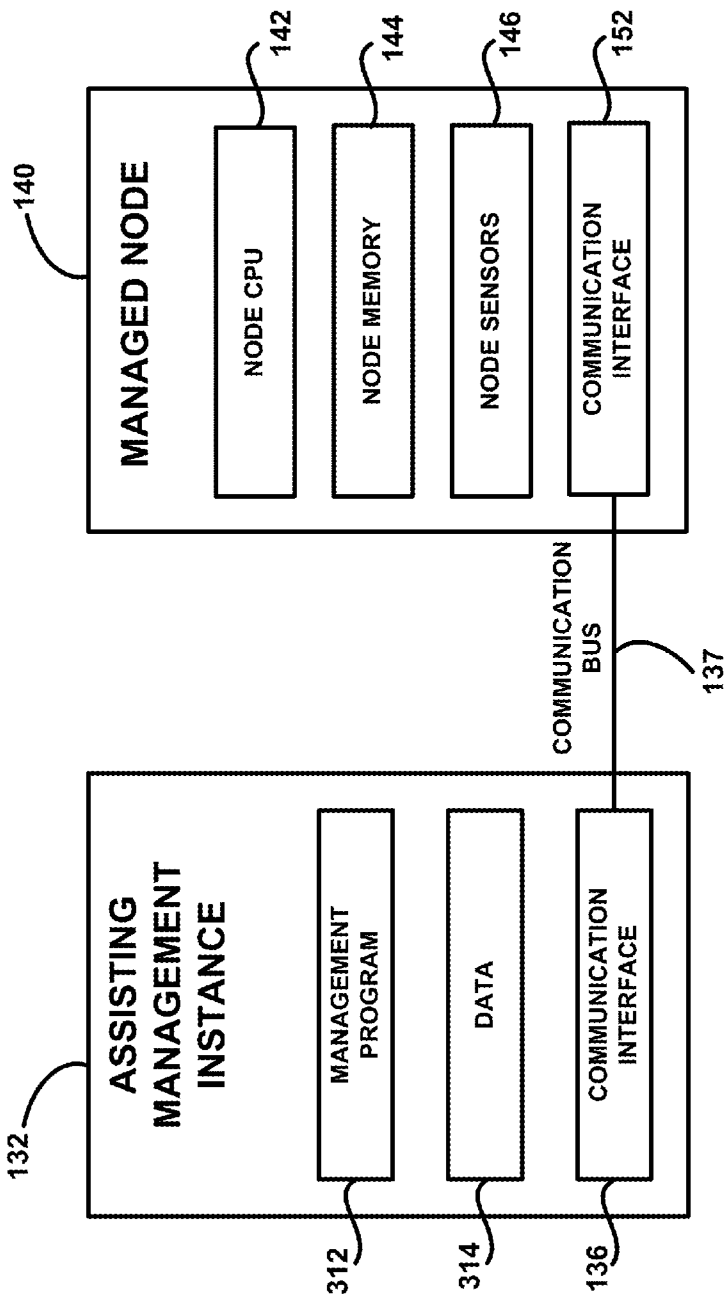

140
MANAGED NODE
NODE CPU
142
NODE MEMORY
144
NODE SENSORS
146
COMMUNICATION INTERFACE
152
COMMUNICATION BUS
137
132
ASSISTING MANAGEMENT INSTANCE
MANAGEMENT PROGRAM
312
DATA
314
COMMUNICATION INTERFACE
136

FIG. 3

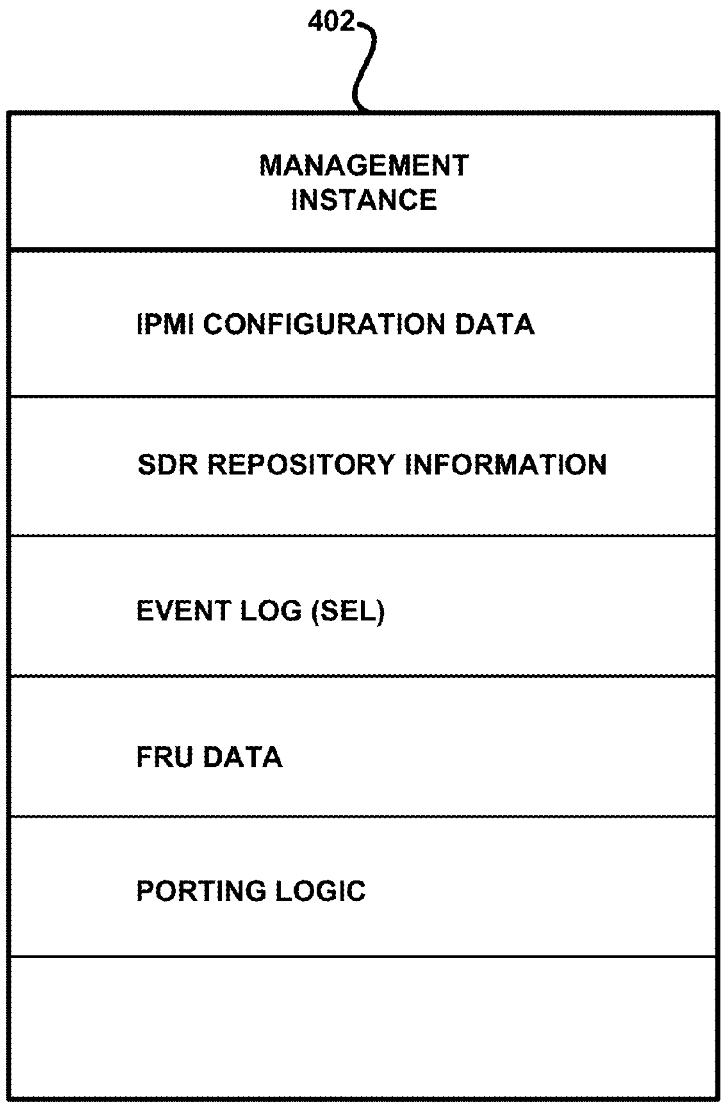

402
MANAGEMENT
INSTANCE
IPMI CONFIGURATION DATA
SDR REPOSITORY INFORMATION
EVENT LOG (SEL)
FRU DATA
PORTING LOGIC

FIG. 4

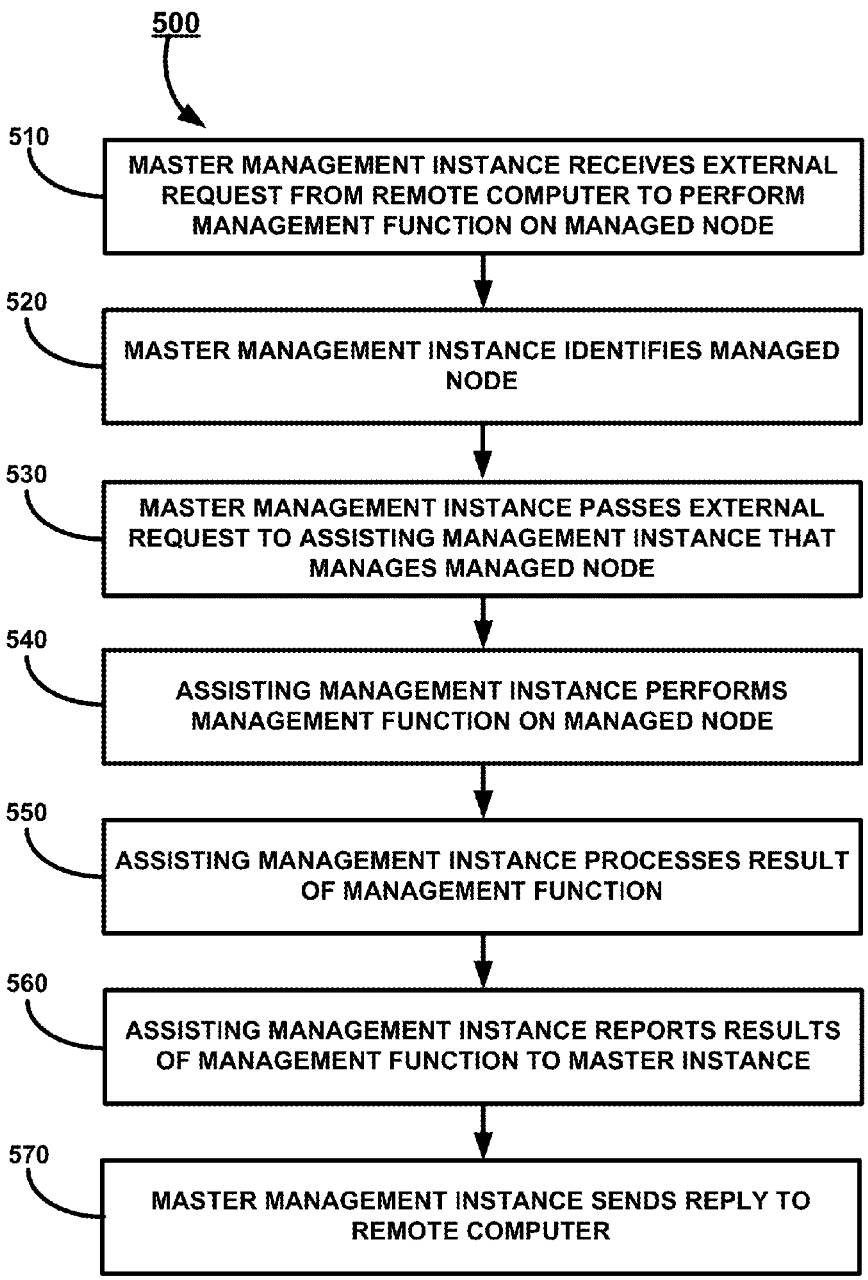

500
510
MASTER MANAGEMENT INSTANCE RECEIVES EXTERNAL REQUEST FROM REMOTE COMPUTER TO PERFORM MANAGEMENT FUNCTION ON MANAGED NODE
520
MASTER MANAGEMENT INSTANCE IDENTIFIES MANAGED NODE
530
MASTER MANAGEMENT INSTANCE PASSES EXTERNAL REQUEST TO ASSISTING MANAGEMENT INSTANCE THAT MANAGES MANAGED NODE
540
ASSISTING MANAGEMENT INSTANCE PERFORMS MANAGEMENT FUNCTION ON MANAGED NODE
550
ASSISTING MANAGEMENT INSTANCE PROCESSES RESULT OF MANAGEMENT FUNCTION
560
ASSISTING MANAGEMENT INSTANCE REPORTS RESULTS OF MANAGEMENT FUNCTION TO MASTER INSTANCE
570
MASTER MANAGEMENT INSTANCE SENDS REPLY TO REMOTE COMPUTER

FIG. 5

CHASSIS MANAGEMENT IMPLEMENTATION BY MANAGEMENT INSTANCE ON BASEBOARD MANAGEMENT CONTROLLER MANAGING MULTIPLE COMPUTER NODES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to copending U.S. patent application Ser. No. 13/736,120, filed Jan. 8, 2013, entitled "EMULATED COMMUNICATION BETWEEN MASTER MANAGEMENT INSTANCE AND ASSISTING MANAGEMENT INSTANCES ON BASEBOARD MANAGEMENT CONTROLLER," and copending U.S. patent application Ser. No. 13/736,150, filed Jan. 8, 2013, entitled "IMPLEMENTATION ON BASEBOARD MANAGEMENT CONTROLLER OF SINGLE OUT-OF-BAND COMMUNICATION ACCESS TO MULTIPLE MANAGED COMPUTER NODES," both of which are incorporated herein by reference in their entireties. The above-identified copending applications have the same assignee as this application and the same inventors as this application.

FIELD

The present disclosure generally relates to firmware of a Baseboard Management Controller for management control of computing platforms, and more particularly to chassis management implementation by a management instance on a baseboard management controller managing multiple computer nodes.

BACKGROUND

Conventionally, multiple pieces of management hardware are required to manage computing functions of multiple computing platforms, where each management hardware device has a single instance of management firmware for a respective one of the computing platforms. There is an associated cost for each computing platform to be managed in a plurality of computing platforms, such as server platforms, because each managed computing platform requires a separate management hardware device. Accordingly, introducing an additional computing platform to be managed means incurring additional cost for the management hardware. The conventional method requires a large amount resources and a large amount cost associated with the resources.

Therefore, heretofore unaddressed needs still exist in the art to address the aforementioned deficiencies and inadequacies.

SUMMARY

Certain aspects of the present disclosure are directed to a baseboard management controller (BMC). The BMC includes a processor and a memory having firmware. The firmware includes a master management instance and a plurality of assisting management instances. When the firmware is executed at the processor, the master management instance is configured to manage a chassis of a computer system, and each of the assisting management instances is configured to manage at least one health or performance related aspect a respective different computer node of a plurality of computer nodes of the computer system.

In certain embodiments, the firmware further comprises a message interface. The master management instance is configured to receive an IPMI message from the message interface, to determine whether the IPMI message contains a chassis management command, and in response to determining that the IPMI message contains a chassis management command, to perform a management action or operation on a first chassis management device of the computer system in accordance with the chassis management command.

In certain embodiments, the IPMI message further contains a first indication to a first chassis management device. The master management instance is configured to determine the first chassis management device from a plurality of chassis management devices of the computer system based on the first indication.

In certain embodiments, the IPMI message further contains first data for constructing an IPMB message. The master management instance is configured to determine whether the first data contains the chassis management command. The master management instance is configured to, in response to determining that the first data contains a chassis management command, not transfer the first data to any of the assisting management instance. In certain embodiments, the master management instance is configured to, in response to determining that the first data do not contain a chassis management command, transfer the first data to one of the assisting management instance.

In certain embodiments, the master management instance and the plurality of assisting management instances each are configured to run on a respective different process. In certain embodiments, the master management instance communicates with each of the plurality of assisting management instances through an inter-process communication mechanism.

Certain aspects of the present disclosure are directed to a baseboard management controller (BMC) implemented method. The method includes: executing, at a processor of the BMC, a master management instance and a plurality of assisting management instances; managing, by the master management instance, a chassis of a computer system; and managing, by each of the assisting management instances, at least one health or performance related aspect a respective different computer node of a plurality of computer nodes of the computer system.

Certain aspects of the present disclosure are directed to a non-transitory computer storage medium having computer-executable instructions stored thereon which, when executed by a processor of a baseboard management controller (BMC), cause the processor to: execute a master management instance and a plurality of assisting management instances; manage, at the master management instance, a chassis of a computer system; and manage, at each of the assisting management instances, at least one health or performance related aspect a respective different computer node of a plurality of computer nodes of the computer system.

These and other aspects of the present disclosure will become apparent from the following description of the preferred embodiment taken in conjunction with the following drawings and their captions, although variations and modifications therein may be affected without departing from the spirit and scope of the novel concepts of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate one or more embodiments of the disclosure and, together with the written description, serve to explain the principles of the disclosure. Wherever possible, the same reference numbers are used throughout the drawings to refer to the same or like elements of an embodiment, and wherein:

FIG. **1**A schematically shows a computer management system having a management device and a plurality of managed computer nodes according to one embodiment of the present disclosure;

FIG. **1**B shows an illustrative flowchart of a chassis management process in accordance with certain embodiments of the present disclosure;

FIG. **2** shows a master instance of the management device according to one embodiment of the present disclosure;

FIG. **3** shows an assisting management instance and a corresponding managed computer node according to one embodiment of the present disclosure;

FIG. **4** illustrates data contents of a management instance according to one embodiment of the present disclosure; and

FIG. **5** shows an exemplary flow chart for the management device to perform a management function on a selected managed computer node according to one embodiment of the present disclosure.

DETAILED DESCRIPTION

The present disclosure is more particularly described in the following examples that are intended as illustrative only since numerous modifications and variations therein will be apparent to those skilled in the art. Various embodiments of the disclosure are now described in detail. Referring to the drawings, like numbers, if any, indicate like components throughout the views. As used in the description herein and throughout the claims that follow, the meaning of "a", "an", and "the" includes plural reference unless the context clearly dictates otherwise. Also, as used in the description herein and throughout the claims that follow, the meaning of "in" includes "in" and "on" unless the context clearly dictates otherwise. Moreover, titles or subtitles may be used in the specification for the convenience of a reader, which shall have no influence on the scope of the present disclosure. Additionally, some terms used in this specification are more specifically defined below.

The terms used in this specification generally have their ordinary meanings in the art, within the context of the disclosure, and in the specific context where each term is used. Certain terms that are used to describe the disclosure are discussed below, or elsewhere in the specification, to provide additional guidance to the practitioner regarding the description of the disclosure. For convenience, certain terms may be highlighted, for example using italics and/or quotation marks. The use of highlighting has no influence on the scope and meaning of a term; the scope and meaning of a term is the same, in the same context, whether or not it is highlighted. It will be appreciated that same thing can be said in more than one way. Consequently, alternative language and synonyms may be used for any one or more of the terms discussed herein, nor is any special significance to be placed upon whether or not a term is elaborated or discussed herein. Synonyms for certain terms are provided. A recital of one or more synonyms does not exclude the use of other synonyms. The use of examples anywhere in this specification including examples of any terms discussed herein is illustrative only, and in no way limits the scope and meaning of the disclosure or of any exemplified term. Likewise, the disclosure is not limited to various embodiments given in this specification.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions will control.

As used herein, "around", "about" or "approximately" shall generally mean within 20 percent, preferably within 10 percent, and more preferably within 5 percent of a given value or range. Numerical quantities given herein are approximate, meaning that the term "around", "about" or "approximately" can be inferred if not expressly stated.

As used herein, "plurality" means two or more.

As used herein, the terms "comprising," "including," "carrying," "having," "containing," "involving," and the like are to be understood to be open-ended, i.e., to mean including but not limited to.

As used herein, the phrase at least one of A, B, and C should be construed to mean a logical (A or B or C), using a non-exclusive logical OR. It should be understood that one or more steps or operations within a method may be executed in different order (or concurrently) without altering the principles of the present disclosure.

As used herein, the term module may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC); an electronic circuit; a combinational logic circuit; a field programmable gate array (FPGA); a processor (shared, dedicated, or group) that executes code; other suitable hardware components that provide the described functionality; or a combination of some or all of the above, such as in a system-on-chip. The term module may include memory (shared, dedicated, or group) that stores code executed by the processor.

The term code, as used above, may include software, firmware, and/or microcode, and may refer to programs, routines, functions, classes, and/or objects. The term shared, as used above, means that some or all code from multiple modules may be executed using a single (shared) processor. In addition, some or all code from multiple modules may be stored by a single (shared) memory. The term group, as used above, means that some or all code from a single module may be executed using a group of processors. In addition, some or all code from a single module may be stored using a group of memories.

The apparatuses and methods described herein may be implemented by one or more computer programs executed by one or more processors. The computer programs include processor-executable instructions that are stored on a non-transitory tangible computer readable medium. The computer programs may also include stored data. Non-limiting examples of the non-transitory tangible computer readable medium are nonvolatile memory, magnetic storage, and optical storage.

The present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the disclosure are shown. This disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Like numbers refer to like elements throughout.

Referring to FIG. **1**A, a conceptual illustration of a computer management system **100** is shown according to one embodiment of the present disclosure. The computer management system **100** includes a management device **120**, and managed computer nodes **140-1**, **140-2**, . . . , and **140**-N, and a chassis **102**. In certain embodiments, the management device **120** can be a Baseboard Management Controller (BMC), and the computer nodes can be computer boards or blade servers plugged onto a back plane in a chassis **100**. The management device **120** communicatively connected to the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N. The management device **120** may be a general purpose computer system. It should be appreciated that the management device **120** may alternatively be a "special purpose" computer system or a system that incorporates more than one interconnected system, such as a client-server network. Indeed, the management device **120** of FIG. **1**A only represents an exemplary embodiment of the present disclosure, and therefore, should not be considered to limit the disclosure in any manner. The BMC **120** will now be used in the description as an example of the management device **120**. One skilled in the art would appreciate that other similar devices can be used in place of the BMC **120**. The BMC **120** includes a processor **127**, firmware **121** stored in memory **123**, and network interface controller **122**.

Intelligent Platform Management Interface ("IPMI") is an industry standard for system monitoring and event recovery. The IPMI specification provides a common message-based interface for accessing all of the manageable features in a compatible computer. IPMI includes a rich set of predefined commands for reading temperature, voltage, fan speed, chassis intrusion, and other parameters. System event logs, hardware watchdogs, and power control can also be accessed through IPMI. In this manner, IPMI defines protocols for accessing the various parameters collected by a BMC through an operating system or through an external connection, such as through a network or serial connection. Additional details regarding IPMI can be found in the IPMI Specification (Version 2.0), which is publicly available from INTEL CORPORATION, and which is incorporated herein by reference.

The BMC **120** can receive an external request such as an IPMI messages **102** through a network interface **126**, which is in communication with the network interface controller **122**, from a remote management computer **108** over a network **104**. The network **104** can be the Internet, a local area network (LAN), or a wide area network (WAN). The BMC can also receive IPMI messages from a management computer **109**, having a CPU **112** and memory **114**, through a system interface **124**. The IPMI message **102** may include, among other things: (1) the source IP/MAC address, (2) a session ID, (3) a sequence number, (4) a Responder's Address, (5) the Responder's Logic Unit Number (LUN), (6) a Requester's Address, (7) the Requester's LUN, (8) actual command CMD, e.g., Send Message, (9) a message Channel number, and (10) encapsulated data for IPMB request. The encapsulated data for IPMB request may include: (1) the Responder's Address, (2) the Responder's LUN, (3) the Requester's Address, (4) the Requester's LUN, (5) the command CMD, e.g., Get Sensor Reading, (6) the sensor number.

The firmware, when executed, can include a master management instance **130** and several assisting management instances, depending on the number of the managed computer nodes. In one example, the firmware also includes a message interface **124**, **126**, a master management instance **130**, and first and second assisting management instances **132-1**, **132-2**. The message interface **124** can include any system interface defined by the IPMI, such as a system interface, i.e., keyboard controller style ("KCS") interface, a system management interface chip ("SMIC") interface, a block transfer ("BT") interface, and SMBus System Interface (SSIF). The message interface **126** can also include a network interface such as an IPMI LAN interface.

The first and second assisting management instances **132-1**, **132-2** monitor at least one health or performance related aspect of first and second computer nodes **140-1**, **140-2**, respectively. The master management instance **130** receives an IPMI message from the message interface **124**, **126**. The IPMI message contains data for constructing an IPMB message. The data includes a first IPMB slave address. The master management instance identifies the first assisting management instance **132-1** from the assisting management instances **132-1**, **132-2**, . . . , **132**-N based on the first IPMB slave address, and then transfers the data to the first assisting management instance **132-1**.

The management instances **130**, **132** can be software stacks that implement one or more IMPI or BMC management functions. In certain embodiments, when the firmware executed by the processor **127**, the processor **127** initiates the master management instance **130** and one assisting management instance **132** for each one of the management computer nodes. In certain embodiments, an assisting management instance **132** has a message interface for communicating with a managed computer node or other devices or systems. The message interface can include the IPMB interface, the ICMB interface, the KCS interface, the SMIC interface, the Block Transfer (BT) interface, the IPMI LAN interface, the SMBus system interface, the IPMI serial/modem interface. In certain embodiments, each of the assisting management instances **132** is in communication with sensors of a managed computer node **140** through a communication link **137** such as a SMBus or an I^2C bus. The assisting management instance **132** performs one or more IPMI management functions for the managed computer node **140-1**, **140-2**, . . . , **140**-N. The assisting management instance **132** can implement all the BMC functions and thus eliminates the need for having a separate BMC installed for each of the managed computer nodes. Optionally, a managed computer nodes can have one Satellite Management Controller (SMC) to perform some of IPMI management functions instead. In certain embodiments, only the master management instance **130** is in communication with the network interface controller **122** through the network interface **126**. The network interface controller **122** can have a single network address (e.g., IP address) and directs all IPMI messages over LAN addressed to that network address to the master management instance **130**. If the remote management computer **108** wants to send an IPMI message to one of the assisting management instance **132**, the remote management computer **108** can send a bridged command that is addressed to the network interface controller **122** to the master management instance **130**. As will be discussed in detail below, the master management instance **130** can relay data contained in the message to the assisting management instance **132**. In other words, communications between the remote management computer **108** and the master management instance **130** and the one or more assisting management instances **132** can be accomplished by using a single network interface controller having a single network address. In this example, there is no need to assign a network address to each of the assisting management instance **132**.

The BMC **120** can utilize the network interface controller (NIC) **122** to receive IPMI messages from, and transmit IPMI messages to, the remote management computer **108**. The BMC **120** includes one or more communication interfaces **136** such as management bus interfaces for communication with the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N through communication buses **137-1**, **137-2**, . . . , and **137**-N. The communication buses **137-1**, **137-2**, . . . , and **137**-N provide two-way communication path for the management device **120** and the IPMI devices of the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N. In certain embodiments, the managed computer node can include a communication interface **152** such as a management bus interface that is coupled to the communication bus **137**.

The component that initiates a communication on a bus is referred to as a “master” component and the component to which the initial communication is sent on the bus is referred to as a “slave” component. A master component therefore issues an initial command to or initially requests information from a slave component. Each slave component is addressed, and thus communicatively accessible to master components, by a particular slave address. Both master components and slave components are operable to transmit and receive communications over the communication bus **137**. Buses and the associated functionality of master-slave communications are well-known to those skilled in the art, and therefore not discussed in further detail herein.

Each of the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N by itself can be a independent computer system include a CPU **142**, a memory **144**, etc. In certain embodiments, a computer node **140**-N can also include an optional satellite management controller (SMC) **148**, one or more sensors **146**, and a communication interface **152**. The SMC **148** and the sensors **146** are in communication with the BMC **120**. The SMC **148** receives IPMB messages from the BMC **120** and perform certain management functions on the computer node **140**-N. The SMC **148** can monitor the operation, performance, and health of the managed computer node **140**-N.

For example, like many electrical components, the CPU **142** dissipates heat while operating. As such, a CPU fan (not shown in FIG. **1**A) can be used to cool off the CPU **142** after the CPU **142** reaches a prescribed temperature. Such a determination, i.e., whether the CPU **142** exceeds a prescribed temperature, can be made by the assisting management instance **132**. As described above, the assisting management instance **132**, through the communication interfaces **136** coupled with the communication buses **137**, with the CPU temperature sensor **146** and the CPU fan to provide monitoring functionality over the temperature sensor and control functionality over the CPU fan.

In general, the assisting management instance **132** monitors operation, performance, and health-related aspects associated with the managed computer node **140**, such as the temperature of one or more components of the managed computer node **140**, speed of rotational components (e.g., spindle motor, CPU Fan, etc.) within the system, the voltage across or applied to one or more components within the managed computer node **140**, and the available or used capacity of memory devices within the managed computer node **140**. The assisting management instance **132** is communicatively connected to the one or more components through the communication interface **136** and the communication bus **137**. In one example, the first assisting management instance **132-1** communicates with a first managed device **146-1** of the first managed computer node **140-1** and that is coupled to the first communication bus **137-1**. In one embodiment, these components include sensor devices **146** for measuring various operating and performance-related parameters within the managed computer node **140**. The sensor devices **146** may be either hardware or software based components configured or programmed to measure or detect one or more of the various operating and performance-related parameters. The assisting management instance **132** may receive this information sensed by the sensors **146** via the communication bus **137** for analysis, and more particularly, for determination as to whether an “event” is occurring within the managed computer node **140**.

The communication bus **137** is used by the BMC **120** to request and/or receive various operating and performance-related parameters from one or more of the plurality of the managed computer nodes, which are also communicatively connected to the communication bus **137**. In certain embodiments, optionally the SMC **148** can also be in communication with the CPU temperature sensor **146** and the CPU fan. The communication bus **137** may include components other than those explicitly shown in FIG. **1**A. Exemplary components not shown in FIG. **1**A may include, without limitation, tachometers, heat sensors, voltage meters, amp meters, and digital and analog sensors. In one embodiment, the communication bus **137** is an Inter-Integrated Circuit (I^2C) bus. In another embodiment, the communication bus **137** is a System Management Bus (SMBus). In a further embodiment, the communication bus **137** is a Low Pin Count (LPC) bus. In certain embodiments, the assisting management instance **132** and the managed computer nodes **140** do not use IPMB to communicate with each other. In one example, the communication bus **137-1** and the communication bus **137-2** use different protocols. In another example, those two communication buses each do not use IPMB protocols.

Firmware may be utilized in the management device **120** that adheres to the Intelligent Platform Management Interface (IPMI) industry standard for system monitoring and event recovery. The IPMI standard is well-known to those of ordinary skill in the industry, and therefore not described in detail herein. Rather, the IPMI Specification, version 2.0 rev. 1.0, published on Feb. 12, 2004 and Revised on Jun. 12, 2009, is incorporated herein by reference.

In one example, the first assisting management instance **140-1** receives the data for constructing an IPMB message from the master management instance **130**, and determines a request to a managed device such as the sensor **146-1** based on an indication in the data. The first assisting management instance **132** then sends the request to the managed device **146-1** through the first communication interface **136-1** and the first communication bus **137-1**. The first managed device **146-1** sends response to the first assisting management instance **132-1**.

In certain embodiments, the BMC **120** has a network interface controller **122** assigned with a network address. The firmware **121** is in communication with the computer nodes **140**. The firmware **121** receives, through the same network interface controller **122**, management requests **102** each for performing a management operation at one of the computer nodes **140** and addressed to the same network address. The management requests are directed to at least two of the computer nodes **140**. The firmware can provide a single out-of-band communication port or access for communicating with all of the computer nodes **140**. In other words, all out-of-band communication directed to the computer nodes can be forwarded by the same network controller **122** to the firmware **121**. The out-of-band communication can be implemented by using network packets directed to the same (e.g. a single) network address of the network interface controller **122**. Thus, the firmware allows all out-of-band communication messages **102** directed to any or all of the computer nodes **140** to be addressed to the same network address and handled by the same network interface controller **122**.

In certain embodiments, each of the management requests includes data for constructing a protocol message in accordance with a selected communication protocol, as long as the communication protocol is capable of directing communication among the computer nodes. In other words, the firmware **121** utilizes the format of the messages of the communication protocol to implement a communication mechanism among the components (such as the management instances **130**, **132**) of the firmware. Further, the firmware **121** can utilize the address mechanism of the communication protocol to identify each of the managed computer nodes **140**. The protocol message can also be utilized to include a management command, which can indicate an action or operation to be applied to a selected computer node **140**. In certain embodiments, after receiving a management request including a message in accordance with the communication protocol, the master management instance can determine, based on the format and content of the message, the management action or operation and which of the managed computer nodes that the action or operation should be applied to. The communication protocols that can be utilized by the firmware **121** include IPMB, ICMB, I^2C, System Management Bus, etc.

In certain embodiments, the firmware **121** can determine a target computer node from the computer nodes **140** based on a protocol address (e.g., IPMB address) in accordance with the communication protocol and included in the protocol message. The firmware can associate each of the computer nodes with a respective protocol address in accordance with the communication protocol, maintain a record of the association of the protocol addresses and the computer nodes **140**, and determine the target computer node by examining the record with a given protocol address.

In certain embodiments, the master management instance **130** provides, to a device communicating with the master management instance **130**, an emulated IPMB communication among the master management instance **130** and the assisting management instances **132**. From the remote computer **108** or the management computer **109**'s point of view, the master management instance **130** represents a first BMC ("master" BMC) and each of the assisting management instance **132** is another BMC ("slave" BMC) or an intelligent platform management controller connected with the master BMC through IPMB. The remote computer **108** or the management computer **109** can send an IPMI bridged request to the master management instance **130**, which in turn transmits the IPMB message encapsulated in the IPMI request to the assisting management instance **132** as indicated in the bridging request. For example, the remote computer **108** can construct an IPMI message with a command set as Send Message. The IPMI message includes data for the IPMB message that is to be sent to a selected one of the assisting management instances **132**. The data for the IPMB message includes the responder's (i.e., the selected assisting management instance's) slave address. From the remote computer **108**'s point of view, it perceives the master management instance **130** and the assisting management instances **132** as master and slave BMCs (or other IPMI controllers) connected with each other through an IPMB bus. The master management instance **130** and the assisting management instances **132** each are assigned an IPMB slave address. In one example, the first assisting management instance **132-1** is identified by the first IPMB slave address. The second assistant management instance **132-2** is identified by a second IPMB slave address. The first and the second slave addresses are different.

In certain embodiments, the remote computer **108** only has the network address (e.g., IP address) of the master BMC (i.e., the master management instance **130**). In one example, the first and second assisting management instances **132-1**, **132-2** do not have a network address assigned specifically for them, respectively. The remote computer **108** embeds the data for the IPMB message in an IPMI message and then encapsulate the IPMI message in network packets (e.g., IP packets) addressed to the master BMC **130**. The IPMI message includes indications that the embedded IPMB data is to be transferred to another selected BMC. The remote computer **108** can obtain the slave addresses of the slave BMCs **132**, which are in accordance with IPMB, through various mechanisms. Thus, the remote computer **108** can include the slave address of the responder slave BMC in the IPMI message constructed. In one example, the IPMI message is encapsulated in at least one network packet having a network address associated with the master management instance **130**. The master management instance **130** receives the network packet through the network interface **126** and then retrieves the IPMI message from the network packet.

In certain embodiments, when the firmware is executed by the processor **127**, the processor **127** spawns at least one master management instance **130** and N assisting management instances, **132-1**, **132-2**, . . . , and **132**-N, one for each of the plurality of the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N. For example, the first assisting management instance **132-1** corresponds to the first managed computer node **140-1**. The second assisting management instance **132-2** corresponds to the second managed computer node **140-2**. The N-th instance **132**-N corresponds to the N-th managed computer node **140**-N.

In certain embodiments, the master management instance **130** initiates a specified number of assisting management instances **132-1**, **132-2**, . . . , and **132**-N, and the number can be configured in a configuration file. In certain embodiments, the master management instance **130** can dynamically discover the number of the computer nodes **140** in the system (e.g., the number of computer boards plugged in the backplane) and initiates the same number of assisting management instances **132**. In certain embodiments, the master management instance **130** assigns a slave address to itself and each of the assisting management instances **132**. The format of the slave addresses is compliant with IPMB. In certain embodiments, the slave addresses are assigned to the management instances **130**, **132** utilizing other known mechanisms. The master management instance **130** keeps a record, for example in a table, of the correlation of the assisting management instances **132** and the assigned slave addresses. In certain embodiments, the master management instance **130** publishes the slave addresses to the remote computer **108** such that the remote computer **108** perceives that a slave BMC **132** managing a respective computer node **140** is assigned a respective slave address on a IPMB bus; an IPMB request can be sent to that slave address to communicate with the slave BMC. The remote computer **108** can also obtain the assigned slave addresses of the perceived master BMC **130** and the slave BMCs **132** through other known mechanisms.

As the remote computer **108** perceives that the assisting management instances **132** as slave BMCs connected with the master BMC **130**, the remote computer **108**, when desires to communicate with a slave BMC **132** managing a particular computer node **140**, will embed data for constructing IPMB messages, including that slave BMC's assigned slave address and the target LUN, in an IPMI message. Upon receiving the IMPI message encapsulated in network packets from the remote computer **108** through the network interface, the master management instance **130** retrieves the IPMI message from the network packets and the examines the fields of the IPMI message. For example, when the master management instance **130** detects that the command field is set as Send Message and that the channel number is 0, the master management instance **130** determines that the IPMI message is to be bridged to an assisting management instance **132**. The master management instance **130** then retrieves the payload data, which was set by the remote computer **108** for a BMC to construct an IPMB message, from the IPMI message.

In certain embodiments, the master management instance **130** and the assisting management instances **132** are executed by the processor **127** and running on different processes initiated by the processor **127**. The master management instance **130** and the assisting management instances **132** implement predefined functions that are known to each other for communication. The master management instance **130** and the assisting management instances **132** utilize inter-process communication mechanisms such as pipe, shared memory, or message queue. In one example, the master management instance **130**, the first assisting management instance **132-1**, and the second assisting management instance **132-2** each run on a respective different process.

The master management instance **130** can generate a unique sequence number, as a tracking ID, for a received Send Message request. The master management instance **130** can also implement a "Pending Bridge Response" table to record the sequence number and information for identifying remote computer **108** that sent the Send Message request. The master management instance **130** calls a function of the assisting management instance **132** to pass the IPMB message data as well as the generated sequence number. The IPMB message data can include the target LUN number, which indicates a device **146** of the management computer node **140**, and the command, which indicates an action to be applied to the identified device **146**. For example, the LUN can indicate a temperature sensor and the command can be "Get Sensor Reading" or "Get Device ID." Alternatively, the master management instance **130** can actually construct an IPMB message with the data and sequence number, and calls a function of the assisting management instance **132** to transfer the IPMB message. The assisting management instance **132** receives the message data and the sequence number or the actual IPMB message, and then retrieves the fields from the data. For example, the assisting management instance **132** can use the LUN to identify a target device and applies an action in accordance with the command. In the above example, the assisting management instance **132** can communicate through the communication interface **136** with the identified temperature sensor **146** of the managed computer node **140** and retrieves the temperature reading or the device ID from the temperature sensor **146**. Upon collecting the information requested, the assisting management instance **132** then sends information and the same sequence number back to the master management instance. Alternatively, the assisting management instance **132** can construct an IPMB response message, including the requested information and the same sequence number, and calls a function of the master management instance **130** to pass the IPMB response message. The master management instance **130** receives the requested information and the sequence number, for example through the IPMB response message, and can lookup the information of the requester (e.g. the remote computer **108**) in the "Pending Bridge Response" table based on the sequence number. After, the master management instance **130** can construct an IPMI response message and encapsulate the response message in a transport format of the requester based on the information found in the Pending Bridge Response Table. In this example, the master management instance **130** will encapsulate the IPMI response message in network packets and transmit the network packets to the remote computer **108** through the network interface **122**.

As an illustrative example, the master management instance **130** can perform following functions:

(1) receiving an IPMI message **102** from a remote computer **108** to bridge an IPMB request to an assisting management instance **132-1** managing a computer node **140-1** through the NIC **122**;

(2) looking up in a table to identify the particular target assisting management instance **132-1** to which the IPMB message is addressed, based on the responders slave address indicated in the IPMI message;

(3) constructing an IPMB request message containing the data from the IPMI message and passes IPMB request message to the target assisting management instance;

(4) receiving an IPMB response message, containing the information requested by the remote computer, from the target assisting management instance; and

(5) constructing an IPMI response message, containing the information requested by the remote computer, and transmitting the IPMI response message to the remote computer through an appropriate message interface **121**, **126**.

In certain embodiments, certain functions described above as implemented by the assisting management instances **132** can be implemented in addition or alternatively by the master management instance **130**. For example, the master management instance **130** can also monitor operating and performance-related parameters of the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N received from the assisting management instances **132-1**, **132-2**, . . . , and **132**-N. The master management instance **130** can determine whether an "event" is occurring within a particular computer node. For example, with respect to the configuration shown in FIG. **1**A, the master management instance **130** can monitor operation of a CPU **142-2** of the second managed computer node **140-2** by request, from the assisting management instance, information of a CPU temperature sensor (not shown in FIG. **1**A) of the sensors **146-2** and a CPU fan (not shown in FIG. **1**A). The requested information can be used to determine whether certain operating or performance related parameters exceed or fall below prescribed threshold ranges of operation. An example of such an event may be the temperature reading of heat dissipated by the CPU **142-2** reaching in excess of 145 degrees Fahrenheit.

In another embodiment, the master management instance **130** may also control one or more of the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N in the computer management system **100** in response to the occurrence of an event. The master management instance **130** may initiate operation of the CPU fan upon determining that the temperature dissipated by the CPU **140** has reached 146 degrees Fahrenheit.

The network interface controller **122** is capable of connecting the management device **120** to a network of remote computers via a network **104**. A remote computer **108** as shown in FIG. **1**A, may be a desktop computer, a server, a router, a network PC (personal computer), or a peer device or other common network node. Networked connections may include a local area network (LAN) or a wide area network (WAN). Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets, and the Internet.

In certain embodiments, the computer system **100** also include a chassis management board **149**. The chassis management board **149** includes various devices and the sensors for performing chassis management functions. For example, the chassis management board can support power-up and power-down of the computer system and environmental monitoring of all units within the chassis **102**. In some examples, the chassis management board can power up and the power down one or more of the computer nodes **140**. In certain embodiments, the chassis management board **149** can perform one or more of the functions of: controlling and monitoring chassis fan speeds; reading system identification (ID) PROMs; monitoring voltage levels and reporting failures; monitoring the On/Off power sequence; monitoring system resets; applying a preset voltage to switch blades and fan control boards. In certain embodiments, the chassis management board **149** can control a front panel display of the chassis **102**. As an illustrative example, the chassis management board **149** has, or is in communication with, one or more chassis fans, one or more chassis fan speed sensors, one or more chassis temperature sensors, and/or one or more power supply devices and sensors. Those devices or sensors **158** of the chassis management board **149** can perform functions such as power on/off, power cycle, reset, diagnostic interrupt, chassis identifications indicator, and system boot, etc.

In certain embodiments, the master management instance **130** can also provide chassis management functions. The master management instance can have a communication interface **153**. The chassis management board **149** has a communication interface **155**. The two communication interfaces **153**, **155** are linked by a communication bus **154**. Thus, the master management instance **130** and the chassis management board **149** are in communication through the communication interface **153**, the communication bus **154**, and the communication interface **155**.

In certain embodiments, the computer system **100** does not have a chassis management board. The sensors or devices **158** described above alternatively can be in communication with the master management instance **130** directly through one or more communication buses. For example, the master management instance (and the BMC) can be in communication with sensors and devices **158** such as chassis temperature sensors, chassis fan speed sensors, and the chassis fan speed controllers through an I^2C bus or SMBus.

In certain embodiments, the master management instance **130** can be implemented to handle one or more of the following IPMI commands: Get Chassis Capabilities, Get Chassis Status, Chassis Control, Chassis Reset, Chassis Identify, Set Front Panel Button Enables, Set Chassis Capabilities, Set Power Restore Policy, Set Power Cycle Interval, Get System Restart Cause, Set System Boot Options, Get System Boot Options, Get POH counter, etc.

As described above, the master management instance **130** receives IPMI messages through the message interface **124**, **126**. The message interface can be the network interface **124** or the system interface **126**. In certain embodiments, after the master management instance **130** receives an IPMI message, it examines the content of the IPMI message and determines whether the content includes a chassis management command. If the IPMI message has a chassis management command, the master management instance **130** then handles the chassis management command itself and does not pass the chassis management command to any of the assisting management instance **132**. This implementation can work well in an environment where the multiple computer node **140** are installed in a single chassis. As there is only one chassis to be managed, typically one management instance (in this example, the master management instance) is capable of managing the chassis functions. It may not be necessary to utilize the other management instance (e.g., the assisting management instance **140**) to handle the chassis management functions.

As described above, the remote computer **108** and the management computer **109** may perceive that the computer nodes **140** as managed by multiple slave BMCs connected by an IPMB bus and behind another master BMC. Where the remote computer or the management computer realizes that the computer nodes **140** are installed in a single chassis **102** and that the master BMC (i.e., the master management instance **130**) manages the chassis **102**, it may send an IPMI message directed to the master BMC and including a chassis management command. In this example, the master management instance **130** receives the IPMI message and retrieves the chassis management command. The master management instance **130** can then performs a chassis management function according to the chassis management command.

FIG. **1B** shows an illustrative flowchart of the chassis management process in accordance with certain embodiments of the present disclosure. At operation **162**, where the remote computer **108** or the local computer **109** considers that a slave BMC behind a master BMC manages a chassis **102**, it may send an IPMI bridged message to the master BMC (i.e., the master management instance **130**). The IPMI bridged message may include data for constructing an IPMB message with a chassis management command. At operation **172**, in certain embodiments, after receiving an IPMI bridged message, the master management instance **130** examines the content of the interface bridged message. At operation **174**, the master management instance **130** determines whether the IPMI message includes a chassis management command directed to the master management instance **130**, or includes data for constructing a protocol message (e.g., an IPMB message) and having a chassis management command. If not, the chassis management process can exit at operation **176**. If at operation **174**, the process determines that there is a chassis management command directed to the master management instance in the IPMI message, process enters operation **178**. Further, if at operation **174**, the operation determines that there is a chassis management command included in the data for constructing the protocol message that is requested to be transferred to an assisting management instance **140**, the master management instance **130** does not transfer the protocol message data, including the chassis management command, to the assisting management instance **140** (i.e., the perceived slave BMC) as instructed by the IPMI bridged message. Rather, the master management instance **130** will handle the chassis management command itself and enter operation **178**.

In certain embodiments, an IPMI message received by the master management instance includes chassis control data having a management command and a device ID. At operation **178**, the master management instance **130** can determine a target chassis management function based on the management command and a target chassis management device to which the function is to be performed based on the device ID. After, at operation **180**, in accordance with the communication interface **153**, **155** and the communication bus **154** between the master management instance **130** and the chassis management devices **158**, the master management instance **130** constructs, using the format of the communication interface **153**, **155**, a request that is addressed to the target chassis management device. The master management instance then transmits the request to the communication bus **154** through the communication interface **153**. The target chassis management device **158**, through the communication interface **155**, listens to the requests transmitted on the communication bus **154**. Upon detecting a request addressed to itself, at operation **190**, the target chassis management device **158** receives the request from the communication bus. At operation **192**, the target chassis management device **158** performs an action or operation in accordance with the request. At operation **196**, if available, the target chassis management device **158** obtains the result of the action or operation. For example, if the target chassis management device **158** is a chassis temperature sensor and the request to the temperature sensor is to get a reading of the sensor, the sensor will accordingly get a temperature reading. At operation **196**, the target chassis management device **158** can construct a response, in accordance with the format of the communication interface **155**, that includes the result of the requested action or operation and that is addressed to the master management instance **130**. At operation **198**, the target chassis management device **158** can then transmit the response to the communication bus **154** through the communication interface **155**.

At operation **184**, the master management instance **130** receives the response form the target chassis management device **158** through the communication interface **153** and the communication bus **154**. At operation **186**, the master management instance **130** constructs an IPMI message that includes the information, if any, requested by the chassis management command. At operation **188**, the master management instance formats the IPMI message in accordance with the transport or communication protocol of the message interface **124**, **126** and then sends the IPMI message to the computer **108**, **109** through the message interface **124**, **126**. For example, where the message interface is a network interface **126**, the master management instance **130** encapsulates the IPMI message in network packets (e.g., IP packets) and transmits the network packets to the network **104** through the network interface controller **122**. At operation **164**, the computer **108**, **109** receives the IPMI message including the requested information from the network. The IPMI message, for example, is encapsulated in network packets.

In certain embodiments, the computer system **100** includes a chassis management board having a chassis management controller (Satellite Management Controller). In this example, the BMC **120** and the master management instance **130** is in communication with the chassis management controller **156** through an IPMB bus. The chassis management controller **156** can perform one or more chassis management functions, which may include one or more of the chassis management functions described above with respect to the master management instance **130**. Stated in a simplified way, some of the above described chassis management functions of the BMC **120** may be assigned or delegated to the chassis management controller **156**.

In certain embodiments, the remote computer **108** (or managed computer **109**) knows the IPMB slave address of the chassis management controller **156**. The remote computer may send an IMPI bridged message requesting the BMC **120** (i.e., the master management instance **130**) to redirect an IPMB message including a chassis management command to the chassis management controller **156**. In this example, the master management instance **130** examines the IPMB data to detect whether the data include a chassis management command. If yes, the master management instance can determine that the IPMB message is directed to the chassis management controller **156** on the actual IPMB bus. The IPMB data may also include an IPMB address assigned to the chassis management controller **156** on the actual IPMB bus. As the master management instance knows that the IPMB message is for an actual device on an actual IPMB bus, the master management instance **130** will not interpret the IPMB slave address as a pointer to a selected assisting management instance **140** as described above. The master management instance **130** can construct an actual IPMB message including the chassis management command retrieved from the IPMI message and addressed to the IPMB slave address of the chassis management controller **156**. Then, the master management instance **130** sends the IPMB message to the IPMB bus through an IPMB interface.

Referring now to FIG. **2**, in certain embodiments, the master management instance **130** includes one or more of the following:

(1) a network interface **122** configured to enable the BMC **120** to communicate with the remote computer **108** via a network connection;

(2) a TCP/IP stack **204** configured to enable the BMC **120** to communicate with the remote computer **108** through the network interface **122**;

(3) a management program **202** configured to perform IPMI management functions;

(4) a web server **206** configured to enable web access from the remote computer **108** with the Internet **104**;

(5) a communication interface **210**, such as a management bus interface, configured to enable communication between the BMC and the plurality of the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N; and

(6) a table **212** for recording correlation between slave addresses and assisting management instances **132**.

In certain embodiments, by providing a web server application program **206**, the master management instance **130** can receive and respond to requests to perform management function via a web interface. Further, according to certain embodiments, the BMC **120** only use one IP address to receive IPMI messages destined to all the managed computer nodes **140-1**, **140-2**, . . . , and **140**-N. In comparison, other implementations may require one IP addresses for each BMC managing a computer node. This can save significant cost and resource.

Referring also now to FIG. **3**, an assisting management instance **132** is shown according to certain embodiments of the present disclosure. Each assisting management instance **132** is initiated to manage one corresponding computer node **140**. The assisting management instance **132** includes:

(1) a management program **312** configured to receive requests such as an IPMB request from the master management instance **130**, to perform management function to a corresponding managed computer node **140**, and to report the responses from the managed computer node **140** to the master management instance **130**;

(2) a data storage **314** configured to store data collected from the corresponding managed computer node **140**; and

(3) a communication interface **136** configured to enable communication between the assisting management instance **132** and the corresponding managed computer node **140** over a communication bus **137**.

The corresponding managed computer node **140** includes:

(1) an optional satellite management controller (SMC) **148** configured to collect data from the managed computer node **140**, to perform certain management functions, and to send data and responses to the corresponding assisting management instance **132**;

(2) a node CPU **142**;

(3) a node memory **144**; and

(4) sensors **146** configured to monitor the health and performance related data of the computer node **140**; and

(5) a communication interface **152**.

The assisting management instance **132** can control and collect information of sensors, sensor data record (SDR) devices, and field replaceable units (FRUs). The assisting management instance **132** can provide one or more of the following exemplary management functions:

(1) power up a node remotely for deployment;

(2) check a node's health condition remotely;

(3) power cycle a node remotely to bring up the cluster configuration after the OS has been deployed;

(4) monitor sensor readings remotely;

(5) monitor system event log (SEL) readings remotely;

(6) provide a remote text console (eliminates one out-of-band management fabric); and

(7) provide remote power management (power up, power down, and/or power cycle).

In certain embodiments, the managed computer nodes **140-1**, **140-2**, . . . , and **140-N** each further include one or more operating systems as well as one or more application programs. The operating system comprises a set of programs that control operations of managed computer nodes **140-1**, **140-2**, . . . , and **140-N**, the management device **120** and allocation of resources. The set of programs, inclusive of certain utility programs, may also provide a graphical user interface to a user. An application program is software that runs on top of the operating system software and uses computer resources made available through the operating system to perform application specific tasks desired by the user. The operating system is operable to multitask, i.e., execute computing tasks in multiple threads, and thus may be any of the following: MICROSOFT CORPORATION's "WINDOWS 95," "WINDOWS CE," "WINDOWS 98," "WINDOWS 2000" or "WINDOWS NT" operating systems, IBM's OS/2 WARP, APPLE's MACINTOSH OSX operating system, LINUX, UNIX, etc.

In one embodiment, as shown in FIG. **4**, the data storage **314** of the assisting management instance **132** stores configuration data, computer health data and/or control parameters collected by the sensors **146** of the managed computer node **140** for performing management functions. The configuration data, computer health data and/or control parameters include one or more of the following:

(1) IPMI configuration data;

(2) sensor data record repository (SDR) information;

(3) system event log (SEL) information;

(4) field replaceable unit (FRU) information; and

(5) porting logic information.

In certain embodiments, the remote computer **108** includes a web browser (not shown in FIG. **1**A), such as the INTERNET EXPLORER web browser from MICROSOFT CORPORATION of Redmond, Wash., that enables the remote computer **108** to communicate over the Internet, local area network (LAN), wide area network (WAN) **106** with the BMC **120**.

FIG. **5** shows a flow chart of exemplary operations according to certain embodiments of the present disclosure. At operation **510**: the management device **120** receives an IPMI request **102** from the remote computer **108**, along with its task—getting the temperature of the CPU **142-2**, and an indication of a target managed computer node **140-2**. An exemplary IMPI request includes one or more of: the source IP/MAC address, the Responder's Address, the Network function code, the Responder's LUN, the Requester's Address, the Requester's LUN, the command, e.g., Send Message, and a message Channel number for example indicating IPMB, encapsulated data for IPMB request. The encapsulated data for IPMB request includes one or more of: the Responder's slave address, the Responder's LUN, the Requester's slave address, the Requester's LUN, the command, e.g., Get Sensor Reading, and the Sensor Number.

At operation **520**, the master management instance **130** identifies the corresponding target managed computer node—**140-2** based on the Responder's Address from a lookup table **212** that maps all the instances. Therefore, the second assisting management instance **132-2** of management firmware is responsible for perform the requested function on the second managed computer node **140-2**.

When the master management instance **130** receives the Send Message command with the 'Bridged Request' parameter bit set, it checks for an available entry in a Pending Bridged Response table and copies parameters from the request to be bridged. When the response is received, these parameters will be used to validate that the response matches the earlier request and to reformat the response for the originating channel.

At operation **530**, the master management instance **130** then forwards the encapsulated data for the IPMB request to the second assisting management instance **132-2** that corresponds to the second managed computer node **140-2** to process the request and perform the management function.

At operation **540**, the second assisting management instance **132-2** communicates, through its corresponding communications interface **316**, with the sensors **146-2** on the managed computer node **140-2**, and to get temperature reading of the CPU **142-2** on the second managed computer node **140-2**. The temperature of the CPU **142-2** is sent back to the second assisting management instance through the second communication interface **316** of the second instance **132-2** and over the communication bus **137**.

At operation **550**, the second assisting management instance **132-2** processes the results and responses of the management function, and stores the temperature of the CPU **142-2** the data storage **314**.

At operation **560**, the second assisting management instance **132-2** send the requested information, e.g., the sensor reading, to the master management instance **130**.

At operation **570**, the master management instance **130** uses the parameters of the original request stored at the master management instance **130**, to reformat the response received from the assisting management instance **132-2** to be in compliance with the originating channel. For example, the master management instance **130** encapsulates an IPMI response message in network packets. The master management instance **130** then sends the network packets to the remote computer **108** through the network interface **126**.

The foregoing description of the exemplary embodiments of the disclosure has been presented only for the purposes of illustration and description and is not intended to be exhaustive or to limit the disclosure to the precise forms disclosed. Many modifications and variations are possible in light of the above teaching.

The embodiments were chosen and described in order to explain the principles of the disclosure and their practical application so as to enable others skilled in the art to utilize the disclosure and various embodiments and with various modifications as are suited to the particular use contemplated. Alternative embodiments will become apparent to those skilled in the art to which the present disclosure pertains without departing from its spirit and scope. Accordingly, the scope of the present disclosure is defined by the appended claims rather than the foregoing description and the exemplary embodiments described therein.

What is claimed is:

1. A baseboard management controller, comprising:

a processor; and

a memory having firmware, the firmware including a master management instance and a plurality of assisting management instances,

wherein, when the firmware is executed at the processor, the master management instance is configured to:

receive an IPMI message;

determine whether the IPMI message contains a chassis management command;

in response to determining that the IPMI message contains a chassis management command, perform a management action or operation on a first chassis management device of a computer system in accordance with the chassis management command; and

in response to determining that the IPMI message does not contain a chassis management command, transfer the IPMI message to one of the assisting management instance; and

each of the assisting management instances is configured to, in response to receiving the IPMI message, manage at least one health or performance related aspect of a respective different computer node of a plurality of computer nodes of the computer system, based on the IPMI message.

2. The baseboard management controller of claim **1**, wherein the firmware further comprises a message interface, wherein the master management instance is configured to receive the IPMI message from the message interface.

3. The baseboard management controller of claim **1**, wherein the IPMI message further contains a first indication to a first chassis management device, and wherein the master management instance is configured to determine the first chassis management device from a plurality of chassis management devices of the computer system based on the first indication.

4. The baseboard management controller of claim **1**, wherein the master management instance is configured to perform at least one of:

controlling and monitoring chassis fan speeds,

reading system identification (ID) PROMs,

monitoring voltage levels and reporting failures,

monitoring a On/Off power sequence,

monitoring system resets, and

applying a preset voltage to a control board of the computer system.

5. The baseboard management controller of claim **1**, wherein the master management instance is configured to perform the management action or operation in accordance with at least one of the following IPMI commands:

Get Chassis Capabilities,

Get Chassis Status,

Chassis Control,

Chassis Reset, Chassis Identify,

Set Front Panel Button Enables,

Set Chassis Capabilities,

Set Power Restore Policy,

Set Power Cycle Interval,

Get System Restart Cause,

Set System Boot Options,

Get System Boot Options, and

Get POH counter.

6. The baseboard management controller of claim **1**, wherein the IPMI message further contains first data for constructing an IPMB message, wherein the master management instance is configured to determine whether the first data contains the chassis management command, and wherein the master management instance is configured to, in response to determining that the first data contains a chassis management command, not transfer the first data to any of the assisting management instance.

7. The baseboard management controller of claim **6**, wherein the master management instance is configured to, in response to determining that the first data does not contain a chassis management command, transfer the first data to one of the assisting management instance.

8. The baseboard management controller of claim **1**, wherein the master management instance and the plurality of assisting management instances each are configured to run on a respective different process.

9. The baseboard management controller of claim **8**, wherein the master management instance communicates with each of the plurality of assisting management instances through an inter-process communication mechanism.

10. The baseboard management controller of claim **9**, wherein the message interface is a system interface or network interface.

11. The baseboard management controller of claim **1**, wherein the firmware is configured to

associate each of the plurality of computer nodes with a respective protocol address in accordance with a first communication protocol, maintain a record of the association of protocol addresses and the computer nodes, and determine a target computer node by examining the record with a given protocol address.

12. The baseboard management controller of claim **11**, wherein the first communication protocol is IPMB protocol and the protocol addresses are IPMB addresses.

13. A baseboard management controller (BMC) implemented method, comprising:

executing, at a processor of the BMC, a master management instance and a plurality of assisting management instances;

receiving, by the master management instance, an IPMI message;

determining, by the master management instance, whether the IPMI message contains a chassis management command;

in response to determining that the IPMI message contains a chassis management command, performing, by the master management instance, a management action or operation on a first chassis management device of a computer system in accordance with the chassis management command;

in response to determining that the IPMI message does not contain a chassis management command, transferring, by the master management, the IPMI message to one of the assisting management instance; and

in response to receiving the IPMI message, managing, by the one of the assisting management instances, at least one health or performance related aspect of a respective different computer node of a plurality of computer nodes of the computer system, based on the IPMI message.

14. The BMC implemented method of claim **13**, further comprising:

executing, at a processor of the BMC, a message interface, wherein the master management instance is configured to receive the IPMI message from the message interface; and

determining, by the master management instance, a first chassis management device from a plurality of chassis management devices of the computer system based on a first indication contained in the IPMI message.

15. The BMC implemented method of claim **13**, wherein the IPMI message further contains first data for constructing an IPMB message, the method comprising:

determining, by the master management instance, whether the first data contains the chassis management command;

in response to determining that the first data contains a chassis management command, not transferring, by the master management, the first data to any of the assisting management instance; and in response to determining that the first data does not contain a chassis management command, transferring, by the master management, the first data to one of the assisting management instance.

16. The BMC implemented method of claim **13**, comprising

executing the master management instance and the plurality of assisting management instances each on a respective different process of the processor; and

the master management instance communicating with each of the plurality of assisting management instances through an inter-process communication mechanism.

17. A non-transitory computer storage medium having computer-executable instructions stored thereon which, when executed by a processor of a baseboard management controller (BMC), cause the processor to:

execute a master management instance and a plurality of assisting management instances;

receive, by the master management instance, an IPMI message;

determine, by the master management instance, whether the IPMI message contains a chassis management command;

in response to determining that the IPMI message contains a chassis management command, perform, by the master management instance, a management action or operation on a first chassis management device of a computer system in accordance with the chassis management command;

in response to determining that the IPMI message does not contain a chassis management command, transfer, by the master management, the IPMI message to one of the assisting management instance; and

in response to receiving the IPMI message, manage, by the one of the assisting management instances, at least one health or performance related aspect of a respective different computer node of a plurality of computer nodes of the computer system, based on the IPMI message.

18. The non-transitory computer storage medium of claim **17**, wherein the instructions, when executed, further cause the processor to

execute a message interface, wherein the master management instance is configured to receive the IPMI message from the message interface; and

determine, at the master management instance, a first chassis management device from a plurality of chassis management devices of the computer system based on a first indication contained in the IPMI message.

19. The non-transitory computer storage medium of claim **17**, wherein the IPMI message further contains first data for constructing an IPMB message, wherein the instructions, when executed, cause the processor to:

determine, by the master management instance, whether the first data contains a chassis management command;

in response to determining that the first data contains a chassis management command, not transfer, by the master management, the first data to any of the assisting management instance; and

in response to determining that the first data does not contain a chassis management command, transfer, by the master management, the first data to one of the assisting management instance.

20. The non-transitory computer storage medium of claim **17**, wherein the instructions, when executed, cause the processor to,

execute the master management instance and the plurality of assisting management instances each on a respective different process of the processor; and

communicate the master management instance with each of the plurality of assisting management instances through an inter-process communication mechanism.

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